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INITIAL INSTRUMENTATION CONSIDERATIONS FOR FEBRUARY 2001 VSHORAD TRIAL

by

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Abstract

This report contains preliminary work pertaining to attendance of a meeting regarding preparations for a Very Short Range Air Defence (VSHORAD) modification version of the expanded chassis Grizzly. There is some documentation of discussions and concepts surrounding the trial and the adaptation of the vehicle. A multiparty approach of scientific personnel from DCIEM covering the fields of toxicology of the air in the vehicle, sound overpressure exposure limits assessment and Javelin rocket motor backblast effects on the gunners with regard to the Javelin Physical Launch Effects (JPLE) training simulator system. The toxicology and sound overpressure work is being done by other DCIEM personnel. The Biomedical Engineering Lab (BME) is to perform video documentation and backblast wind velocity analysis in coordination with the other two activities. This report describes preliminary thoughts and analysis on the matter.

Executive Summary

A device was designed and produced for locking the azimuth and elevation of the Lightweight Multiple Launcher (LML). It was test fitted with a real aiming unit and found to need a slight revision to one mount clamp and a connecting link bar. The possibility of designing and making a remote trigger control was raised. Issues of toxic substances generated by heating of the vehicle from the rocket flames were discussed. Video might reveal flame impingement, thermal sensors could possibly detect surface overheating, but direct detection of noxious substances superceded any of those methods for detection of overall unhealthy conditions. High speed video was discounted as a method for detecting a tail cap strike because of the difficult video conditions with the presence of the 1st stage rocket motor smoke. Regular NTSC video was left as a fall back method. Some background information was provided about issues in using field measurement equipment. It included effects of the launch and environment on equipment in previous trials and general observations about the nature of a training firing. Measurements of rocket motor wind backblast velocities were desired for comparison with velocities from trench firings, where trench firings had previously been used as a calibration reference for the JPLE. The initial thoughts for velocity measurement were to view smoke or debris moving through the field of view in the video.

Résumé

Le présent rapport traite des travaux préliminaires présentés lors d'une réunion sur les préparatifs d'une version modifiée du système de défense aérienne à très courte portée (DATCP) montée sur châssis allongé de Grizzly. Quelques documents traitent des discussions et des concepts relatifs aux essais et à l'adaptation du véhicule. Le personnel scientifique de l'IMED a utilisé une approche collective pour couvrir les domaines de la toxicologie de l'air dans le véhicule, les limites d'exposition à la surpression acoustique et l'évaluation des effets causés par le souffle à l'arrière du propulseur du système Javelin sur les servants de l'arme avec le simulateur d'entraînement des effets physiques de lancement de Javelin (JPLE). Des travaux de toxicologie et de surpression acoustique sont également effectués par d'autres membres du personnel de l'IMED. Le Biomedical Engineering Lab (BME) va réaliser un documentaire vidéo et analyser la vélocité du souffle en coordination avec les deux autres activités. Ce rapport décrit les impressions et analyses préliminaires sur le sujet.

Sommaire

Un dispositif a été conçu et produit pour verrouiller le lanceur multiple léger (LML) en azimut et en élévation. Le dispositif a été mis au point avec une unité de pointage véritable. De légères modifications doivent être apportées à la bride de fixation de l'affût et à une barre de liaison. L'idée de développer et de fabriquer une commande de mise à feu à distance a été discutée. Les problèmes des émissions de substances toxiques produites le chauffage de la surface du véhicule par l'action des flammes des missiles qui ont également été discutés. Le filmage sur vidéo pourrait mettre en évidence l'impact des flammes. L'utilisation de capteurs thermiques pourrait permettre de déceler la surchauffe des surfaces, mais la détection directe des substances nocives est supérieure à toutes ces méthodes pour révéler l'ensemble des conditions nuisibles pour la santé. On a rejeté le vidéo en accéléré comme méthode d'observation de la percussion du capuchon arrière à cause des conditions difficiles de filmage vidéo (présence de la fumée émise par le premier étage de la fusée) et on a retenu à la place l'utilisation d'un vidéo NTSC. Quelques informations générales ont été fournies sur l'utilisation du matériel de mesure en campagne, notamment en ce qui a trait aux effets du lancement et de l'environnement sur le matériel lors d'essais précédents et à des observations générales sur la nature des tirs d'entraînement. Les mesures de vélocité du souffle arrière du propulseur étaient destinées à faire des comparaisons avec celles de tirs effectués depuis des tranchées et qui avaient servi de référence d'étalonnage pour le simulateur JPLE. Les impressions initiales en matière de mesures de vélocité étaient basées sur l'observation de la fumée et des débris éjectés visibles sur l'enregistrement vidéo.

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Introduction

There is an intention to have a field trial where some aspects of firing the Javelin missile system from a to-be-modified armoured vehicle, the Very Short Range Air Defence (VSHORAD) modification version of the expanded chassis Grizzly, will be studied. The proposed method of firing in final field application is to open a hatch on the vehicle, assemble an aiming unit plus canister for shoulder firing, and fire from the shoulder while standing in the open hatch. In the scientific field trial, the proposed method of firing is to mount a Lightweight Multiple Launcher (LML) in the hatch, on a platform where the gunner would normally stand, and remotely control the firing while the various scientific instrumentation operated. This method was conceived to remove risk to personnel during the first firings of an unproven configuration.

There was previous activity in this ongoing project of developing and adapting the Grizzly into its VSHORAD variant. The military contact or leader for the project is Major Bouchard, with a key assistant being Captain Bouffard. It was considered that there should be a team of people from the Defence and Civil Institute of Environmental Medicine (DCIEM) addressing various measurement issues related to safety of operations when firing from the vehicle. The key safety issues were acoustic blast overpressure and toxicity. Additionally it was suggested that there would be value in Captain Ron Bishop and his human factors support staff performing a study related to accommodating the anthropometry of the soldier population in the dimensions and style details chosen for the key physical modifications to be done to the Grizzly. These modifications were a hatch near mid-vehicle, large enough to allow firing while small enough to prevent backblast and smoke ingress, a raised platform to elevate the soldiers within the hatch during firing and a movable seat for an observer type function, used for regular closed hatch travel and for observation during travel.

Mr. Brian Crabtree will provide acoustic overpressure analysis in conjunction with Mr. Denis Lebel from the Munitions Experimental Test Center (METC), who will execute the field audio measurements. Dr. Jiri Zamecnic with assistance from PO2 Margaret Lever and Mcpl. Mark Switzer, all from DCIEM, will do toxicology testing related primarily to air sampling and quality testing for toxic substances.

An initial invitation for Mr. Hall from the Biomedical Engineering lab (BME), previously known as the Operator Robot Interaction lab (ORI) to participate was extended because of previous involvement in Javelin firing camps and because of involvement in the development of the Javelin Detachment Trainer (JDT). It was suggested that video capabilities could be provided if the Land Forces Test and Evaluation Unit (LFTEU) (formerly Test and Evaluation or T&E Gagetown) was not available for that purpose. There was also suggestion that some form of instrumentation and observations could be made about possible new implications for the calibration of the Javelin

Physical Launch Effects (JPLE) system used in the JDT. There was some initial talk of using the BME lab high speed video capabilities to identify if the brief flames from the Javelin rocket motor impinged on the Grizzly vehicle. There was also initial talk regarding the possibility of conceiving and creating a remote firing method for the Javelin Aiming Unit, pending the possibility that the Javelin manufacturer, Shorts Brothers, would not be able to provide such a capability or device.

The proposed team from DCIEM attended a meeting June 20th, 2000 at the General Motors Heavy Equipment plant in London. At this meeting Major Bouchard gave a presentation describing the overall vehicle modification project, leading to the issues surrounding the VSHORAD variant of the Grizzly and the potential involvement of the DCIEM personnell. A key observation was that an existing mode of Javelin use, referred to as "taxi" mode, was a fall back method of operation if there were insurmountable problems in developing the details of firing from on the vehicle. There had been historical design approaches. One by the National Research Council (NRC) had noted there was enough room to fire from the circular opening left when one removed the turret from a standard Grizzly. It was noted that the current design thinking was aimed more at having a rectangular hatch. The anticipated general procedures for the personnel executing a Javelin firing from on the vehicle were described. The basic premise was then proposed, that an unmanned instrumented firing should be carried out so as to confirm it was safe enough to perform manned firings. Some generalities of and possibilities for field testing were discussed leading to trying to tie the tests onto the October 2000 mobility tests. It was decided to make a DCIEM test plan with schedule by the end of August, including times and costing to see if it would fit into the overall project budget and scheme. It was expected that the human factors work could proceed as early as late September. The meeting included a walk-in of a Command Post (CP) Bison vehicle which had an 18" longer back section than the Grizzly and other smaller changes. Some video was taken of the vehicle to record its nature for review. Some video was also taken of WO Reid explaining and performing the loading and firing drills for the Javelin in shoulder launch mode. Hand notes and the minutes from the meeting are contained in Appendix A.

Upon return to DCIEM the various team members prepared proposals. The BioMedical Engineering (BME) lab proposal originally encompassed making an azimuth and elevation locking aparattus for the LML, possibly stepping in and supporting T&E in efforts to video the behaviour of the smoke, possibly providing high speed video taping (250 frames/sec) and analysing wind velocity patterns from video to see where the smoke went and to find whether the velocities were comparable to those from previous trench based firings (the trainer was calibrated based on trench firing data). As this proposal was being formulated, the issue of how to use the high speed video was thought over.

The main objectives of the high speed video were to capture possible tail cap strikes on the vehicle and to capture possible rearward, 1st stage rocket motor flame impingement on the vehicle

which had the potential of generating toxins via interaction with the Chemical Agent Resistant Coating (CARC) paint on the vehicle. At this time, in August 2000, an additional information package was forwarded from Major Bouchard. This package contained some answers to specific technical questions from the London meeting. Among them were the composition of the rocket propellant and characteristics of the 1st stage motor backblast. Two graphs were given, one of air pressure in bars overlaid on Plume radius vs Axial length and the other of temperature overlaid on Plume Radius vs Axial Length. These are in Appendix B. It was noted that the graph was of temperature and did not directly describe the extent of the flames in the blast. The chemistry and toxins expert, Jiri Zamecnic, was asked whether there was a distinction between heat causing chemical reactions and direct contact with flames causing chemical reactions. The response was either that there was no chemistry difference or that it was not significant if it was there or that it had no impact on the measurements that were to be taken. In short, no detailed explanation was available and the issue was brushed aside. However, at the same time someone (who?) interpreted the issue to mean that it would be necessary to measure the temperature of the vehicle surface to see if it heated up enough to generate toxins.

At a later stage it was discovered and confirmed with Shorts that the provided pressure and temperature data was for the second stage motor and hence could not be used for the intended analysis of events at the vehicle, which involve the first stage motor. First stage motor data was requested from Shorts directly and it was discovered that pressure measurements existed but that temperature measurements were unavailable.

At some informal meetings at DCIEM explanations of reasoning were given regarding the high speed camera related issues. With respect to being able to see whether a tail cap strike occurred, it was noted that in previous video from side views the flash from the burning motor obliterated the view by whiting it out and that this was precisely when the tail cap moved through the picture. Hence it was expected that despite the speed of the camera, the duration of the flame coincided with the travel time for the tail cap through the camera view and hence the tail cap would not be seen. With regard to the heat vs flame contact issue, some basic thermodynamics analysis was applied to the concept of measuring the vehicle surface temperature. The situation is extremely dynamic, with the applied heat almost being an impulse with sub 1 second duration. Most contact or physical temperature equalization based temperature sensors (sensor inserted/attached and equalizes to temp of immediate surroundings/object attached to) depend on reaching a state of thermal equilibrium, which, in combination with the experimenter's knowledge of the equilibrium temperature gradients in the system, allow the experimenter to know the indicated temperature is that of what they wanted to measure. The more dynamic the situation and the larger the heat flows, the less accurate the measurement is. In the case of the Javelin 1st stage backblast, the heat transient is very quick and the vehicle surface temperature gradient is shallow spatially but noticeable temperature wise. These are the worst possible circumstances for a temperature measurement. In addition to that, the "object" of interest for measurement is the thin surface layer of CARC paint.

The presence of the sensor on top of the paint makes the sensor be present in series with the thermal path and create its own dynamic thermal response characteristic which almost guaranteed will not match that of the thin layer of paint. Hence in the special case that a rapid responding sensor such as a micro thermistor (perhaps 1/10 second response) was used, it would not have the correct thermal dynamic. The response of that thermistor to the impulse would be measured, not the response of the CARC paint layer. Even if the CARC paint temperature was measured to some degree of success, knowing that value would not indicate whether it had caused the generation of toxins by overheating or chemically reacting with the paint. Hence, overall, visibly seeing the flames contact the vehicle via high speed video or via extreme efforts measuring the CARC paint temperature would only secondarily indicate some likelihood of generation of toxins. By virtue of all the discounting factors and the extra effort required for non-direct information about toxicity, initial plans to possibly use high speed video were scrapped.

Another issue was the mockup of the vehicle hatch would be CARC painted "soft metal" (aluminum) and not CARC painted steel like the real vehicle is made from, so the dynamic thermal response of the CARC paint surface layer would again be different in the final situation. On that issue, one could note that aluminum has a different heat conductivity and heat capacity and hence a surface heating transient would result in a different surface temperature on the aluminum than on the steel. In passing, it was noted that there is a U.S. version of the CARC paint which is very toxic when heated and a Canadian version of the paint which is less toxic. The Grizzly uses the U.S. version of the paint and the soft metal mockup was planned to be painted with the U.S. version of the paint.

The final conclusion with regard to the high speed camera providing information was that it would not see a tail cap strike from the side view which would be the view required to best see evidence of a strike. Based on that, the initial BME lab contribution to the DCIEM test proposal was revised to describe that high speed video would not be of any practical use for those specific purposes. This information was forwarded to Captain Ron Bishop October 4/2000 in the form of edited revisions to the BME section of the DCIEM team testing proposal. The first version of the proposal and the emailed/revised pages are contained in Appendix C.

A summary of the proposed test activities from Appendix C is as follows. Mr. Bart Hall will be involved in video data acquisition and measuring 2nd stage motor backblast wind velocities or patterns, as possible, to corroborate the air sampling tests and to check for consistency of the firing experience in the new configuration vs the traditional trench firing experience, upon which the training system was calibrated. There would also be some analysis of interacting factors or considerations for the variety of test equipment and firing configurations which will be addressed as a general issue of planning equipment setup. A specific task would be for Mr. Hall to make a bracing system to lock the azimuth and elevation of the LML. The rest of the report deals with

these issues in more detail. The report also covers observations and developments that resulted from a meeting on November 14th and 15th, 2000 at T&E Gagetown and other information.

Design and Manufacture of Azimuth and Elevation LML Brace

The basic issue with regards to the LML was to set it up both in an unmanned fashion and also position it in such a way that it best located the active missile canister as if it was being fired from the shoulder. The intention is to locate the missile canister properly because the resultant tail cap ejection, rearward 1st stage motor flame and gases, and 2nd stage motor flames and gases ought to be aligned and spaced appropriately with respect to the vehicle. This spacing or geometry is the main objective because the anticipated problems are with the missile smoke entering the hatches of the vehicle, generation of possible toxic by-products from the missile heat or direct flame contact with the vehicle (or its Chemical Agent Resistant Coating (CARC) paint), and damage from the ejected canister tail cap striking the vehicle.

Properly simulating the shoulder-launched geometry was also important because interaction of the vector of the 2nd stage rocket motor backblast and the physical structure of the vehicle with occupants sitting on the local terrain determines the wind blast velocity patterns. The local wind pattern at the gunner determines the nature of the physical disturbance the gunner endures during firing. This blast of wind matters in several ways. It creates a substantial flow dynamic that would greatly affect the entry, settling or clearing of residual gases inside the vehicle. The blast itself is a source of unwanted rocket engine smoke. The nature of the blast needs to be matched to the training system physical effects calibration so that the trainer can adequately prepare the gunners for live firings. The blast can also actually be a safety concern, if it is strong, because the proposed arrangement for the gunners has them standing with a larger portion of their upper bodies exposed to the blast, thus creating more rearward force than in a traditional trench firing. Safety becomes an issue because the gunner could fall within the hatch or could fall right off the vehicle if they lost their balance and/or footing. This stems from support around the hatch being at knee to mid-thigh level with the currently proposed configuration.

The first observation was that the gunner unlocks the pivoting upper assembly and controls its aim in both azimuth and elevation. This observation implied that there was a need for an adjustable locking mechanism wherein the system could be aimed and then locked. The second observation was that the LML would have to be held down securely inside the vehicle, on the raised platform where the gunner would normally stand. Based on observations of previous field trials and on having an LML in the BME lab, it was noted that the three support legs spread out in a particular fashion (one to the rear and two symmetrically to the front) and occupied a substantial amount of space. The LML barely fit inside the safety trenches normally used for training firings.

Having visited the facility where the armoured vehicle designated for modification was available for viewing, combined with a knowledge of the basic intended configuration, it was observed that the original LML legs would not fit inside the vehicle on the gunner platform. Thus fastening the LML to the platform also became a notable design challenge.

The prototype platform for inside the vehicle is to be made from wood. It has not been ascertained at this time specifically where the LML is to be mounted on the platform. The only understanding is that it is to simulate the scenario of two people, Gunner and Commanding Officer, standing side by side performing a shoulder-supported firing. They are also to fire in various directions such as might occur in real use. When normally firing from the LML, one pivots the head assembly on the central support post. However, for the tests the objective is to position the canister where it would end up if the two people were firing from the shoulder. This canister position results both from how the canister plus aiming unit is held and from where the gunner ends up standing within the hatch opening. The design for the azimuth-elevation aiming lock is such that the positioning of the LML within the hatch will not affect it. That positioning and its implications will be ascertained later in the activities.

Two main concurrent scientific tests to be performed are acoustic blast overpressure and air toxicity quality. A third test of lesser importance is monitoring of local wind patterns in terms of how they buffet the gunner and how they affect the distribution of the smoke and gases generated by the missile. To this end, some mannequins will be positioned in the vehicle to provide some sort of effects similar to those that would be generated by the normally involved personnel in terms of acoustic reflections and absorptions and blockage or alteration of air patterns. With these factors in mind it is proposed that the LML aiming lock and mounting/anchoring be as unobtrusive as possible.

It was stated that T&E Gagetown would make some version of an azimuth and elevation lock, but it was not known precisely what form it would take. With this in mind, pictures of that version of a brace were requested and forwarded. Those pictures are shown in Figures 1 and 2.

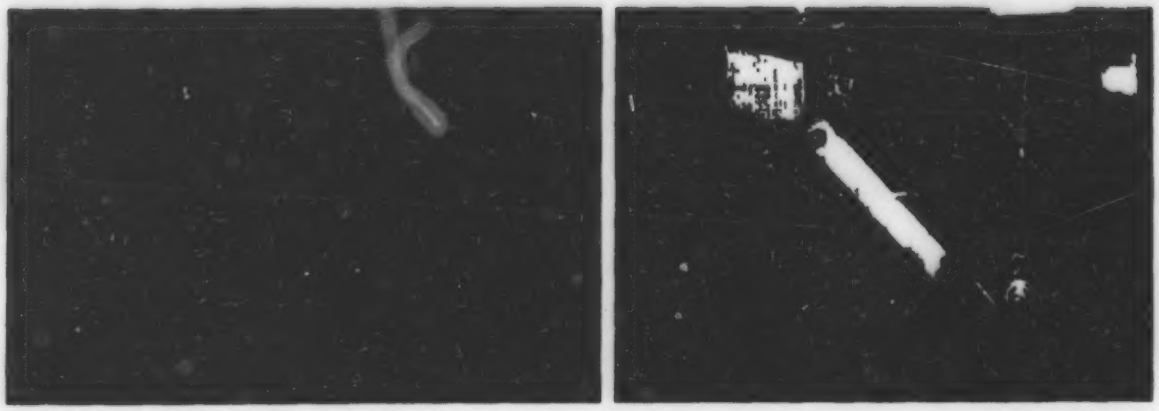

Figure 1 T&E Gagetown Javelin LML Azimuth and Elevation Locking Brace

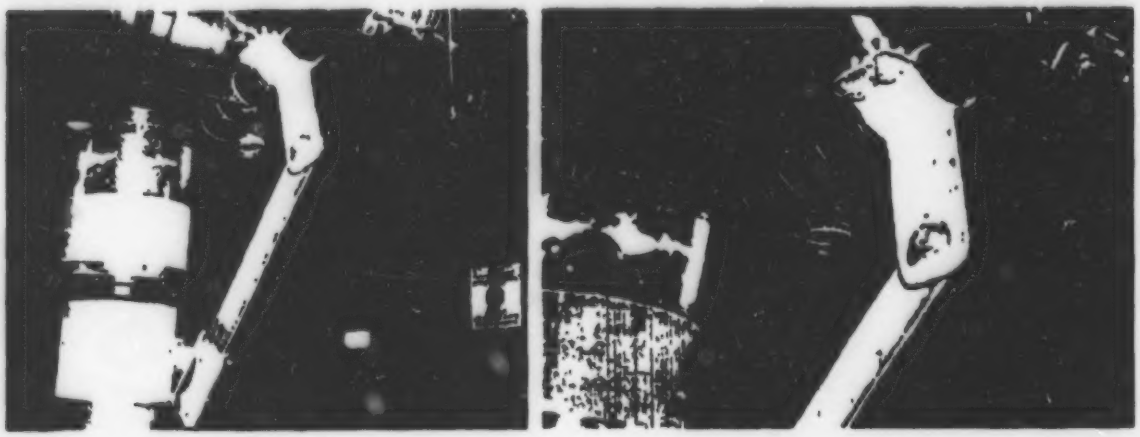

Figure 2 T&E Gagetown Javelin LML Azimuth and Elevation Locking Brace

The design looked viable but looked like it might have a weakness in holding azimuth in a rigid fashion. It was a bit hard to see in the pictures, but it appeared that the torsion loading onto the main support post from locking azimuth was being transmitted to a single stud bolt that was presumably welded to the main post clamping sleeve. The size of that bolt could not be readily ascertained, but a second potential weakness was spotted in that the longer piece sliding brace link was made from band-like stock and was subjected to bending in its weak direction (i.e. like flexing a ruler). Structural failure of the longer piece was not expected, but flexible behaviour was expected. If the brace had looked satisfactory, no azimuth and elevation locking brace would have been pursued at DCIEM. However, on seeing these weaknesses, a brace was designed which

because of the nature of the problem, was very similar to the T&E brace except that torsional rigidity was of equal concern as elevation rigidity. Nearly the same deign was produced except the cantilever stress on the weak stud bolt was removed and the longer piece link was made to be rigid against bending. The DCIEM brace is shown in Figure 3, as it was before going to Gagetown.

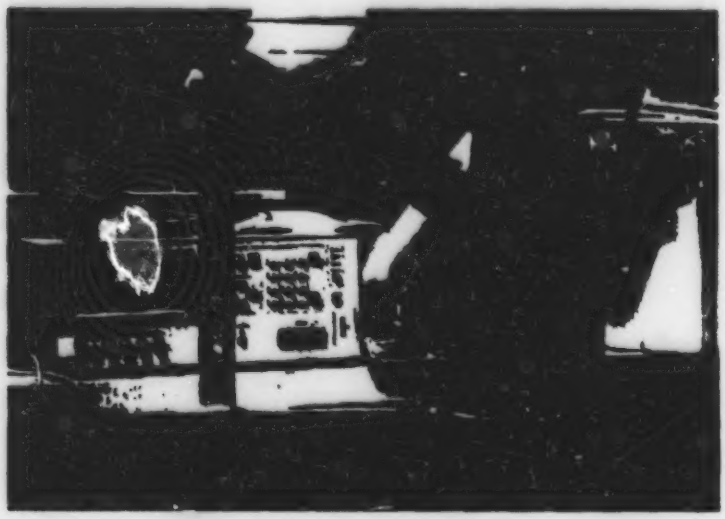

Figure 3 DCIEM Javelin LML Azimuth and Elevation Locking Brace

The critical dimensions for making the brace are as follows. The main collar was a 6" O.D. slab, near 3" high with a 4.247" to 4.250" hole bored in it (allowing .005 to .008 total diameter clearance on the 4.242" O.D. LML center post). The 6 clamp screws were 1/4"-UNC 20. A coarse thread was chosen in consideration of field use, some dirt and use of a larger Allen key. The horizontal beam was solid 2"x 3/4" aluminum bar stock approximately 9" long. The dimension 9" was chosen to allow the brace link to be nearly vertical so it would experience the least stress levels (pure bending instead of mixed in torsion; least stress = max attained rigidity). The horizontal link was chosen to be very large because it experienced cantilever bending and torsional loading. The TIG weld fillets at its base were made very large to ensure that maximum rigidity would be attained. It was considered to use a large solid bar as the vertical link, but it was felt that with the very rigid horizontal bar, and the friction-held clamp on the LML's support bar, the vertical link would have to deform in an "S" shape and hence, because of their constraints, the vertical bar would behave in a more rigid fashion than if it was simply cantilevering. This is only true to the degree that the LML arm is locked in snugly with its lock screw/thumb wheel. If it has play, the vertical bar acts only as a cantilever. Even so, it is still substantially rigid.

The upper clamp was a block large enough to leave room for the clamp screws and was bored to 1.500" +.003/-.000 to fit the horizontal LML arm. The clamp screws were again 1/4"

UNC20, but with their heads trimmed to slightly less than 0.375" diameter so they would fit inside a 0.375" dia. countersink done with an end mill so as to have a flat shoulder. The countersink depth was maximised within reason to bring the heads down. This was to minimise the material thickness near the aiming unit. The 1.500" bore hole was placed at 0.750 + 0.125" = 0.875" so that the material would be 0.125" thick, good enough for strength but as thin as prudent. It was recalled that the LML camera mount previously made needed to have a very thin clamp material. It was also considered that the material could be cut thinner after the fact if it did not fit. The only critical distance for that block was to have its other face 2.835" + 0.75"/2 = 3.210" from the 1.500" hole center. This was to accommodate the 2.835" offset between the LML main vertical support center and the LML horizontal support center.

The length of the 1"x1"x.125" wall aluminum vertical bar was determined by mounting the two clamp pieces on the LML, positioning the LML at 6° and then at 35° elevation, and marking the 1/2" diameter hole locations with a felt pen. Very large 1/2"UNC13 high grade bolts were used to ensure no fouling of threads and to ensure no possibility at all of a bolt snapping off. It was regarded that keeping the live missile aimed downrange was of very high priority.

The installation of the device was originally designed as follows. The LML has a height adjustment ring that can go 20 turns for a height change of 9.96". During the last 4.46" of up travel, an inner ring protrudes out from the main spin collar, blocking access to clamping on the main post. To accommodate this protrusion and a 35° elevation angle, a 22" vertical bar was required! This reduced its rigidity substantially, so the shortest possible configuration was sought. That configuration came partly, and fortunately agreeably, with the need to make the LML short to simulate a shoulder firing. Shoulder heights, that is at the point of contact, under load, with the missile canister when shoulder firing, were measured to be 52.5" on a very short person and 62.5" on a tall male, chosen respectively to be 5% and 95% representatives within the military population. Those same contact points on the canister, as held in the lowest slot in the LML (position 3) were between 60.2" and 61.7", with the specific number depending on whose shoulder and whether the LML was at 6° or 35° elevation. Hence the LML, at its shortest adjustment, could simulate the right height for a tall male (6'4") but could not simulate the height of a short female (4'11"?), and would probably be in error by being about 10"/2 = 5" too high to represent an average person. It helped the design when the LML had to be set to it's lowest height, because that resulted in the shortest, most rigid vertical link. The main post collar was slid up when installed so that it would touch the LML adjustment spin collar. The upper clamp bock was installed midway on the 9" LML horizontal bar. One upper hole was drilled in the vertical bar, and two lower holes were drilled, one representing a 6° aiming elevation and one for 35° aiming elevation. An earlier thought had been to make it adjustable and to build a protractor with markings into the design. That was passed on for the present because the unmanned test firings were apparently to occur at 6° and 35° only. In case of error or last minute modification, it was planned that an other simple bar could be marked while

the angles were measured with a level and new holes drilled in a very short time. An adjustable, slotted vertical link could also be easily provided with minimal effort. The final bar length was about 18".

During the welding of the horizontal bar on the semi-cylindrical half-clamp, the weld fillet pulled the semicircle to a larger diameter such that the clamp screw holes did not line up by about 0.040". The aluminum proved to be soft enough that it was pushed back by squeezing it in a vise. In fact, it was so soft it was squeezed too tight on the first try. The piece was then stood up on end on a 2x4 to prevent metal deformation, and the 2"x3/4" bar pounded once on its end with a 10 lb sledge hammer. This increase the diameter again by about 0.008 and the bolt hole lined up well enough to use. In the end, the 2"x3/4" bar was on center but angled slightly so that a small spacer was required at the top block to accommodate the offset. This was undoubtedly caused by heat stresses from welding one side's fillet completely while only tacking the other side, and then proceeding to finish the fillet on the other side a second step.

Upon attending the meeting November 14th and 15th, 2000 at T&E Gagetown better pictures of the T&E locking brace were obtained. They are shown in Figures 4, 5 and 6.

Figure 4 T&E Gagetown Javelin LML Azimuth and Elevation Locking Brace- Final

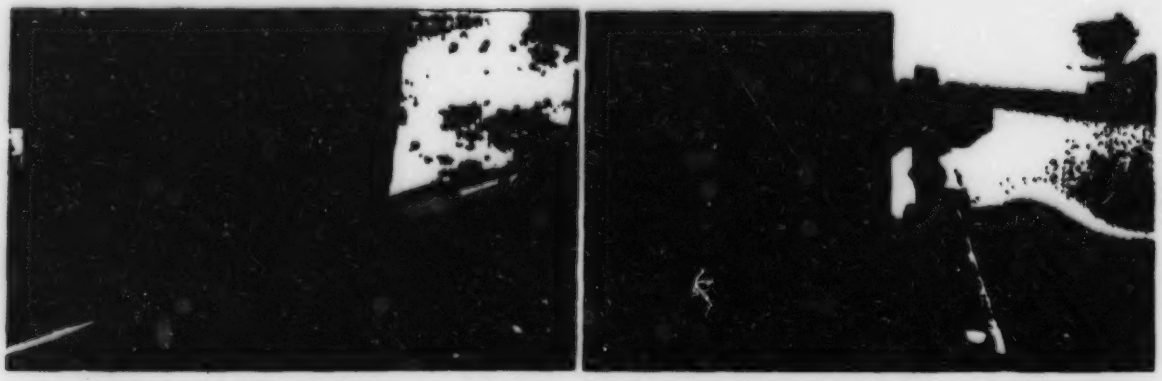

Figure 5 T&E Gagetown Javelin LML Azimuth and Elevation Locking Brace- Final

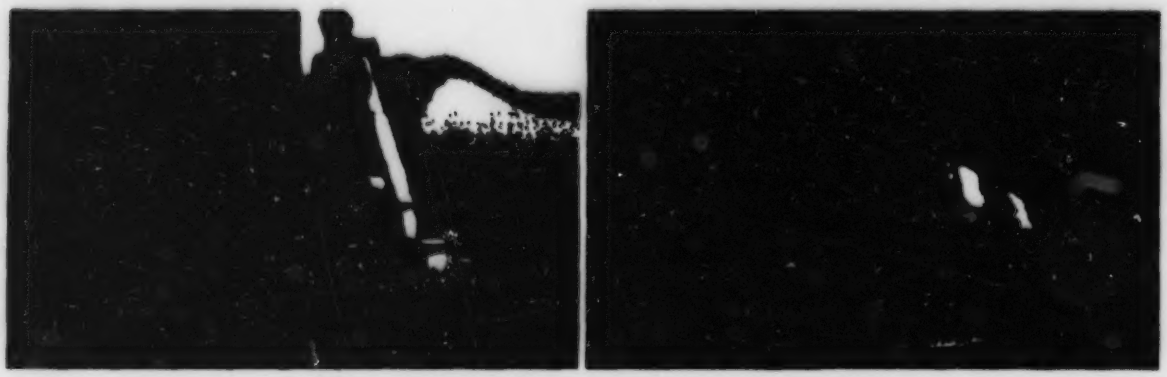

Figure 6 T&E Gagetown Javelin LML Azimuth and Elevation Locking Brace- Final

The presence of flexure and the idea of potential weakness of the single stud bolt welded to the main collar was confirmed.

The DCIEM azimuth and elevation locking brace was test fitted on the LML with an S15 aiming unit. The specific nature of the requirement for a thin portion on the upper clamp block was confirmed. This first test fitting is shown in Figures 7, 8 and 9.

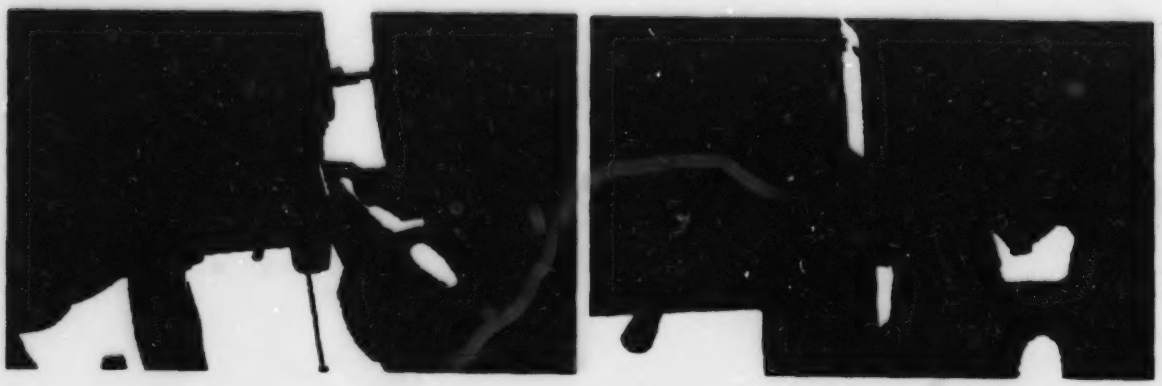

Figure 7 DCIEM Javelin LML Azimuth and Elevation Locking Brace Test Fit - Tight Gap Between Trigger Guard and LML Horizontal Bar

The military who assembled the LML said they had difficulty getting the aiming unit on after installing the upper clamp. They said they had to put the aiming unit on first and then tighten on the upper clamp. A very close inspection, as shown in Figure 7 illustrated that the gap between the trigger guard and the LML horizontal post was much smaller than originally thought. The gap could not be measured because there was no vernier available, so it was recorded graphically in the photo as being as wide as the trigger guard casting was thick, guessed to be perhaps 1/16" thick. It was concluded that the on-LML camera plus microphone previously made had been installed not at the trigger guard location, but in the open space closer to the base of the horizontal arm. In that location, there was enough play between the aiming unit and saddle to allow the aiming unit to angle sideways and slide off for dismounting or slide on for mounting. However, it was desired to keep the azimuth/elevation brace very strong, so shaving it down a lot to allow aiming unit installation and removal was not a good option. Instead, the upper corner of the clamp block cap was cut down to maximize clearance between it and the aiming unit, and the clamping location was reassigned to be more outward on the arm. A rule of thumb basis was chosen of "one block thickness" inward from the furthest out position (1.625"). This dimension was chosen to allow reasonablly easy calibrated installation without needing a vernier or ruler. This placed the upper clamp somewhat near the original mid-bar location, but far enough ahead to clear the tight gap by the aiming unit handle. In Figure 8 the upper clamp was loose and had slid to its most outer possible location.

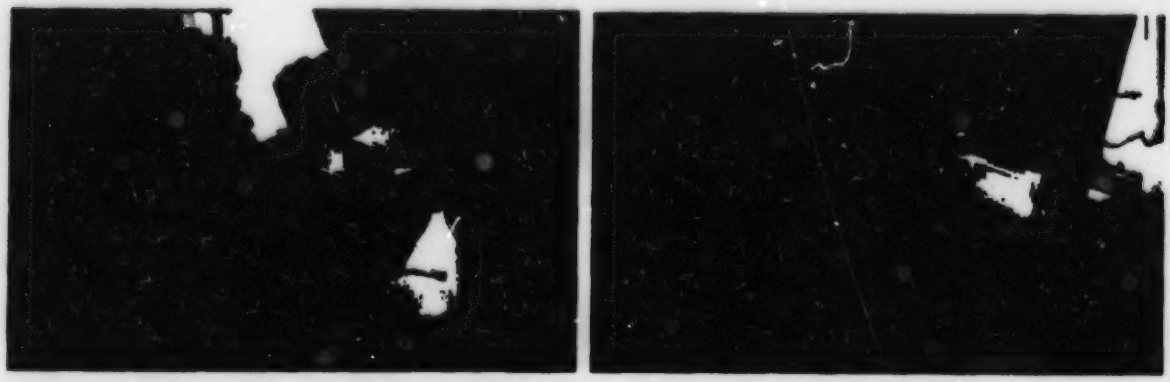

Figure 8 DCIEM Javelin LML Azimuth and Elevation Locking Brace Test Fit

It can be seen that the lower clamp, on the main vertical support tube, is slid up to touch the black cover tube of the height adjuster. This was with the height adjuster in its lowest possible position.

Figure 9 DCIEM Javelin LML Azimuth and Elevation Locking Brace Test Fit - In Vehicle

In Figure 9 the LML was simply stood up on the mockup wooden box platform with the three legs preventing it from falling over. The LML was roughly positioned to the right side of the vehicle as possible and forward as possible, this being allowed by when the LML legs protruded out to touch the vehicle inner walls. The angle was set to the 35° bolt hole, but the angle was not accurate because the LML tilted slightly forward and the upper brace clamp was not in its original location midway on the horizontal LML bar. It was estimated to be about 4° too low, or near 31°

elevation angle.

Aspects of Real Javelin Missile Firings

Several Blazing Archer live firing training camps have been attended in the past. Some practical observations were made. The tail cap leaves the canister at high speed. The backblast from the 2nd stage motor is very substantial, to the point where a gunners helmet could be jarred by it. That backblast carries debris and dust with it, all of which impinges the gunner. The patterns of wind in the backblast are somewhat apparent by observing the debris, but it is particularly apparent that the local breeze at the time of the firing determines when and where the smoke ends up. Of practical implication is that the 2nd stage backblast exerts a noticeable disturbance force on the gunner and LML. This implies that the LML mounting and locking should be sturdy. A more strict requirement would be to have rigidity in the mounting and locking so that there would be minimal deviations in the aim of the system during the course of a shot. In order to have rigidity, not only the LML and its mounting/locking need be rigid, but that to which they are attached ought to be rigid and sturdy. This passes a design feature on to the gunner platform, and potentially to the hatch cover if it is used in any way to support the LML or mannequins.

There has been a typical elevation angle in trench and the few Vehicle Mounted Launcher (VML) training firings. A few pictures have been included with superimposed measurement reference lines.

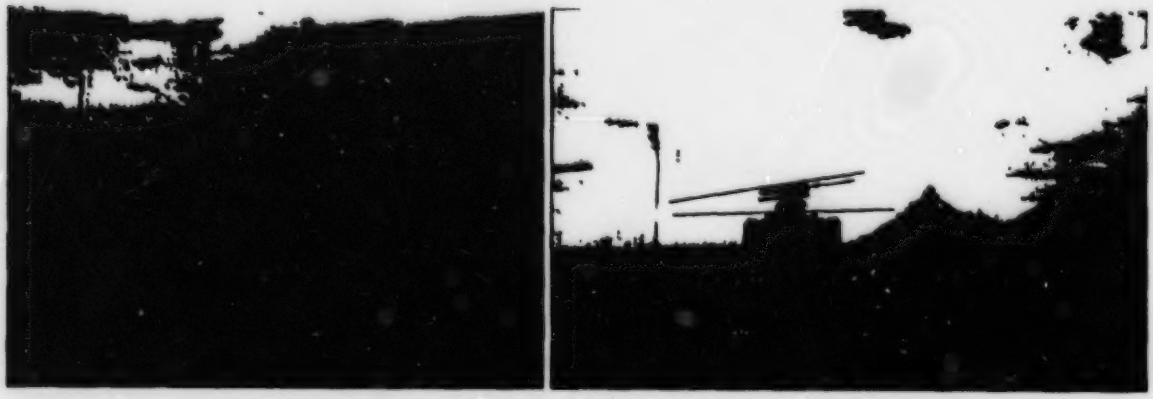

Figure 10 Vehicle Mounted Launcher (VML) Elevation Angle at Training Firings

In the left picture of Figure 10 the firing angle was 6° elevation as measured from the vertical line aligned with the vehicle body. In the right picture it was 7.2° elevation as measured from the vehicle body.

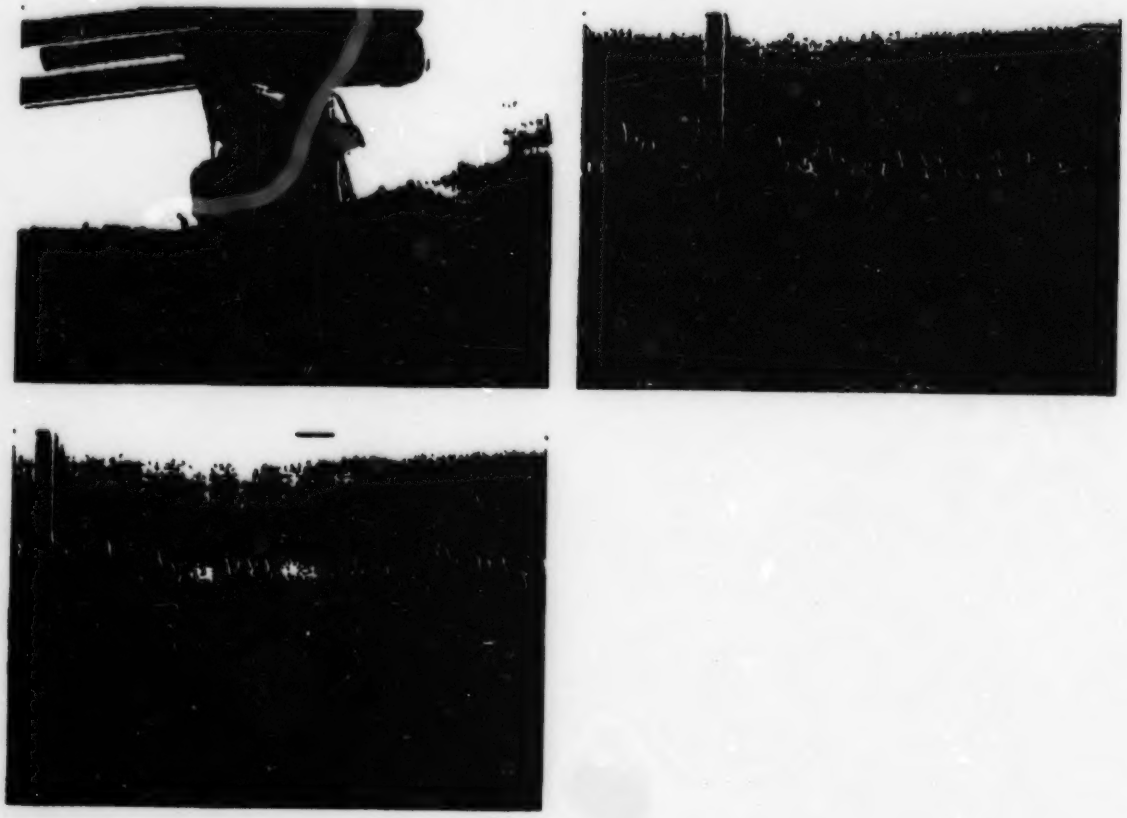

Figure 11 Lightweight Multiple Launcher (LML) Elevation Angles at Training Firings

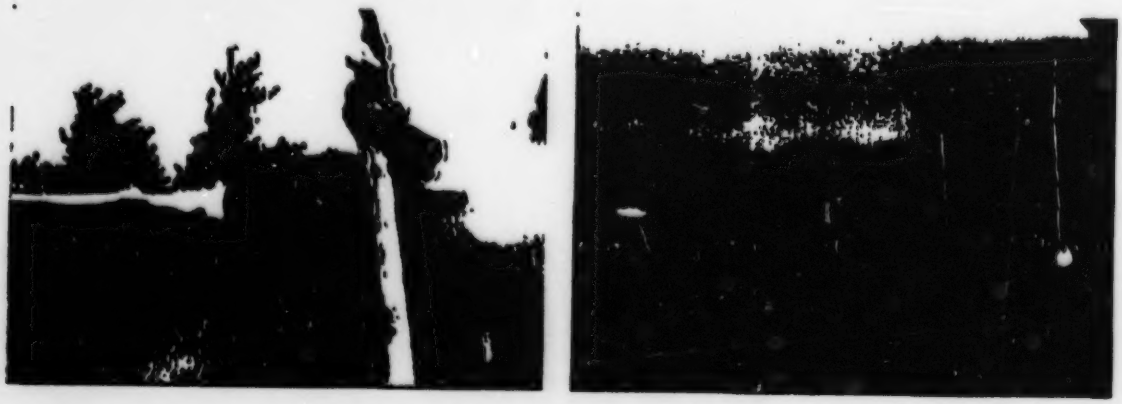

Figure 12 Shoulder Supported Elevation Angles at Training Firings

In Figures 11 and 12, all the elevation firing angles were 6° plus or minus a small amount. It is suspected that this was a result of the relatively uniform altitude and bearing the target drones approached from combined with the desired minimum target distance before which it was preferred that the gunners fired. The azimuth aiming was confined to be within the designated arcs of fire downrange.

There are other aspects of real firings that might be considered with regard to operating experimental equipment. One concern is the dust and debris that is blown around with each shot. With luck, the ground may be damp to reduce the dust. However, when the ground is damp it usually means there are some condensation problems for electrical equipment either due to the humidity and temperature or possibly because it has just rained, and then everything is generally wet. It has been common at earlier field trials (at Javelin firings) to have wide variation of the weather during each day. The most inclement weather encountered so far on a Javelin field trial at which instrumentation was attempted by the BME lab has been cold temperatures above freezing combined with rain. In these conditions there were problems with the video equipment until the sun dried up a good deal of the humidity coming out from the soaked ground and foliage.

A perhaps unexpected problem was the physical shock to equipment caused by the blast overpressure from firing. At the first trial attended, the computer in the trench froze upon the first missile going down range. For a later trial the computer was housed in a wooden box which damped the acoustic shock and allowed it to run successfully. It has been repeatably seen that the acoustic shock affects the relationship between VCR recording heads and the tape, causing an aberration in the tape at the right time according to allowing for the distance and time for the sound pressure wave to reach the tape deck or handycam. For this reason remote camera heads transmitting to a base area video monitoring and recording station is desirable. Recording at a distance of perhaps 20 or 30 meters would still experience the tape aberration effect. This was discovered to be true when recording from a distance this close, which was allowed because of access to a safe haven in the adjacent firing trench at one field trial (a person is not normally allowed to be this close due to safety constraints).

The requirement for safety allowed only periodic access to the equipment stationed at the firing point. Once the missiles were live and present at the firing point, especially loaded into the launcher, access was not permitted. This restriction caused the development of remote control capabilities for quite a bit of the equipment used by the BME lab at previous trials.

Discussion and Recommendations

The general observations are that attention will have to be paid to field robustness of the equipment used and that there will be interactions between the equipment. The presence of cameras can interfere with the wind flow patterns and the presence of objects will affect the physics of the sound acoustics. The placement of the missile canister during firing relative to the vehicle and personnel determines the physics of the acoustics and airflow, in addition to determining the likelihood of a tailcap strike on the vehicle. In accordance with the objective of the instrumentation of the trial, which is to measure the physical effects one would experience during a manned firing, it is recognized that the correct placement of the canister is necessary to create those conditions. To that end, the placement of the LML will be different for each shot in an effort to correctly place the canister where it would be situated during a shoulder supported shot. Some method of ascertaining where the gunner and commander stand within the hatch for each firing direction will be used for future work in designing the LML to vehicle brace so it can position the LML correctly within the hatch. At the present time, movement of the rocket smoke in the video is the intended velocity measurement method, without the addition of visible smoke or particulate matter which may interfere with air quality measurement or visual guidance of the missile. Direct wind velocity instrumentation is a possibility for additional work. Such measurements ought to also be carried out at the trenches at CFB Petawawa where the original JPLE calibration mostly came from.

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14. ABSTRACT

(U) This report contains preliminary work pertaining to attendance of a meeting regarding preparations for a Very Short Range Air Defence (VSHORAD) modification version of the expanded chassis Grizzly There is some documentation of discussions and concepts surrounding the trial and the adaptation of the vehicle A multiparty approach of scientific personnel from DCIEM covering the fields of toxicology of the air in the vehicle, sound overpressure exposure limits assessment and Javelin rocket motor backblast effects on the gunners with regard to the Javelin Physical Launch Effects (JPLE) training simulator system The toxicology and sound overpressure work is being done by other DCIEM personnel. The Biomedical Engineering Lab (BME) is to perform video documentation and backblast wind velocity analysis in coordination with the other two activities This report describes preliminary thoughts and analysis on the matter.

15. KEYWORDS, DESCRIPTORS or IDENTIFIERS

(U) Very Short Range Air Defence (VSHORAD
Javelin air defence missile
shoulder-supported missile launching

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